Test Procedure for Oil Filled Power Transformer

1- Mechanical Checks and Visual Inspection.
2- Electrical Tests
   2.1. Core insulation Resistance test.
   2.2 Winding Insulation Resistance test.
   2.3. Winding Resistance Test.
   2.4. Excitation Current Measurements.
   2.5. Insulation Power factor.
   2.6. Vector Group Test.
   2.7. Calibration of winding temp.Indicators.
   2.8. Calibration of Oil temp.Device.
   2.9. Percentage Impedance Test.
   2.10. Turns Ratio Test.
   2.11. 12, 13, 14.Inspection of fans and MCBs.
   2.15. On-Load tap Changer tests.
   2.16. Bushing Current Transformer Tests.
   2.17. Functional Checks for mechanical protection devices.
   2.18. Insulation Oil Tests.

1-Mechanical Checks and Visual Inspection

1. Open the impact recorder, remove the graph and check for abnormal impact during transit.
2. Check that all components are installed.
I.e. Bushings, Buchloz relay, protective device for OLTC, Oil and Winding Temp. Indicators, Fans, breather, etc….
3. Check quality of paint, lifting lugs, welding areas, wheel stoppers.
4. Check nameplate information for rated Power, voltage, current, frequency
5. Check tightness of all bolts (torque wrench method).
6. Check all grounding is securely connected.
7. Check that the piping Buchloz relay has proper slope.
8. Check that the tank pressure is positive.
9. Check that all valves between tank and radiators are open.
10. Check all Bushings for damage.
11. Check Breather for quantity, colour and oil level.
12. Check Heaters and Humidity meters in local panel at correct setting.
13. Check that phase marking in cable box matches with GIS and cables.
14. Check that hoses, pipes and fan protection not rubber or plastic.
15. Check the vertical and horizontal clearance of live parts.
16. Check integrity of air bag in the conservator.
17. Check labelling of all auxiliary devices as per approved drawings.
18. Check proper operation of auxiliary devices.
Cooling fans, OLTC, Oil level gauges, top oil temp. gauges, Buchloz relay,
Winding temp. Gauges, OLTC pressure relay, push buttons, indicators, oil sampling, Main Tank valves ….
19. Check oil leakage by apply 0.35 kPa for 24 Hrs.
20. Check that oil samples valves are accessible from ground level.
21. Check all external wiring for correctness and tightness.
22. Check operation of on-line gas monitoring system --if installed.

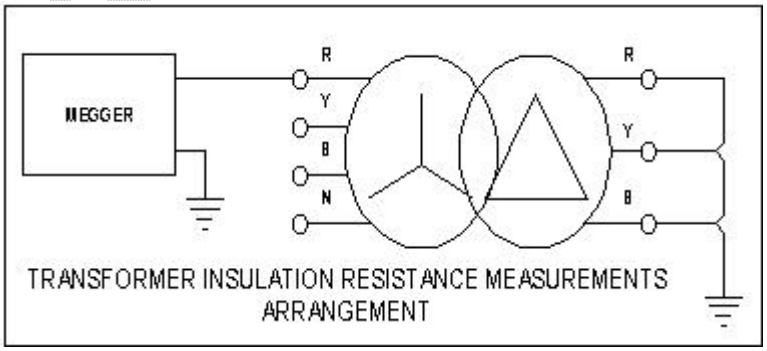
2- Electrical Tests

1. Core insulation Resistance test

Test Equipment: Digital Insulation Tester
- Open the core cover on the top of the main tank.
- Disconnect the grounding connections.
- Using insulation tester connect the +ve terminal to the core bushing and –ve terminal to ground.
- Apply 1000V and record the insulation resistance at 1min. in Mega Ohms.
- After test make sure the ground connection securely connected.

2. Winding Insulation Resistance test

Test Equipment: Digital Insulation Tester
- Make sure that all bushing are free, clean, the main tank is grounded.
- Make short circuit between H.V bushings and L.V bushings, T.V bushings separately
- Using 5000v insulation tester, connect +ve terminal to H.V bushings and –ve terminal to ground while L.V, T.V bushings are grounded.
- Apply 5000v; record the insulation resistance of H.V windings at 1min. and 10 min. in Mega Ohms.
- Calculate the polarization Index by dividing R@10min. By R@ 1 min.
- Repeat for L.V and T.V.



TRANSFORMER INSULATION RESISTANCE MEASUREMENTS ARRANGEMENT

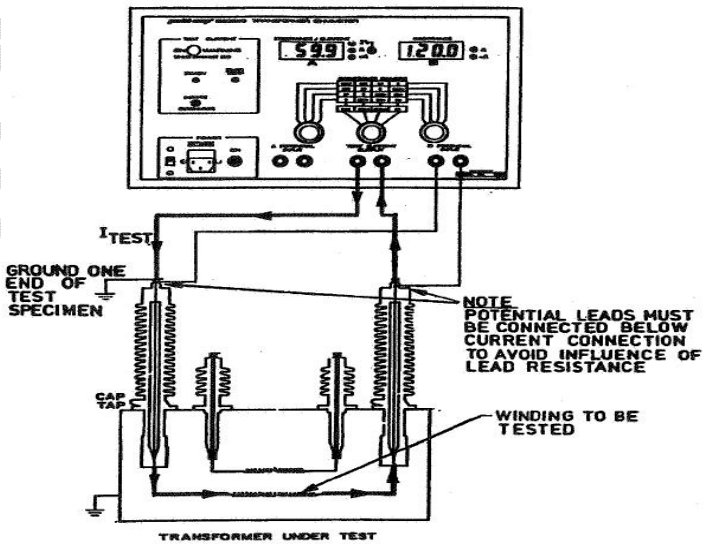
3. Winding Resistance Test

Test Equipment: Transformer Ohmmeter "TRO"
- Winding Resistance will be measured by DC voltage drop method
- The test will be done on each tap position for the H.V windings
- The tester injects multi-range DC current through the current leads and senses the voltage drop across the coil through voltage leads
- Record the Oil temp.
- Connect the current leads on (R-N) in the H.V side
- Connect the Voltage leads on (R-N) in the H.V side
- Be sure that the leads are good connected and that the voltage leads are close the winding than the current leads
- Select the suitable current range according to the resistance value
- Start injection and wait till the tester read a constant resistance value
- Record the winding resistance
- Record the Oil temp.
- Refer this reading to 75˚C as follows

R@75˚C = R@ ambient x correction factor

; Correction factor = (A+ 75) ÷ (A+ ambient temp.)

; A is constant (A=234.5 for copper, A= 225 for aluminium)
- Repeat for all tap positions
- Repeat for other phases (Y-N) and (B-N) for H.V side
- Repeat for L.V and T.V



4. Excitation Current Measurements

Test Equipment: Insulation Power Factor Test Set

- The test will be done at High side, while the low side open
- Using AC Insulation Test set DELTA2000 select Transformer Excitation Current Measurements Mode.
- Connect the circuit as shown below for (assume vector group Delta- star)
- Connect the High voltage cable to phase H1 and Red cable to H2 while grounding the neutral point of the low side
- Inject 10KV gradually and record the excitation current (mA) each 1KV increment.
- Repeat for (H2-H3) and (H3-H1).

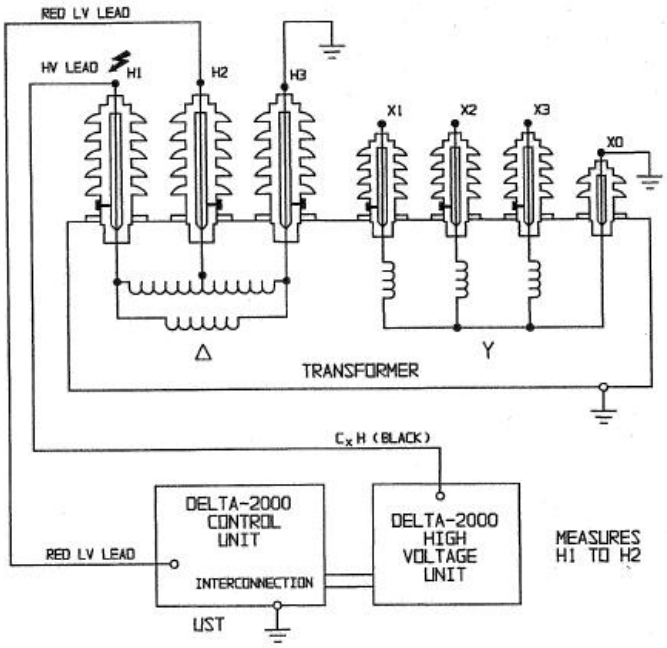


Figure 7: Typical Test Setup for Transformer Excitation Current Measurements

5. Insulation Power factor

Test Equipment: Insulation Power Factor Test Set

- The test is done for measuring the quality of insulation medium and the capacitance between each side and ground
- The insulation power factor should be minimum (<0.5 %)
- Make sure that all bushing are free , clean , the main tank is grounded
- Make short circuit between H.V bushings and L.V bushings, T.V bushings separately
- Using DELTA 2000 AC insulation test set assume two winding power transformer
- For insulation power factor for H.V windings connect high voltage cable to H.V and red cable to L.V as shown below
- Adjust the test mode to the required mode
  GST: Grounded Specimen Test
  UST: Un-Grounded Specimen Test
- Inject 10KV and record mA, Watts, Capacitance, and P.F
- Record Oil Temp. And refer the measured insulation power factor to 20°C by multiplying by correction factor. (In Standard tables)
- Repeat for different test modes
- Repeat for L.V
- The test will be done also for Bushings by connecting the high voltage cable to the power terminal and the red cable to test tap of the bushing and selecting UST test mode

N	Capacitance	Test Mode	Connections			Test voltage KV
			ENG	GND	GAR	
1	$C_{(H-G)} + C_{(H-LV1)}$	**GST**	H.V	LV1	LV2	10 KV
2	$C_{(H-G)}$	**GST**	H.V		LV1,LV2	10 KV
3	$C_{(H-LV1)}$	**UST**	H.V			10 KV
4	$C_{(LV1-G)} + C_{(LV1-LV2)}$	**GST**	LV1	LV2	H.V	10 KV
5	$C_{(LV1-G)}$	**GST**	LV1		H.V,LV2	10 KV
6	$C_{(LV1-LV2)}$	**UST**	LV1			10 KV
7	$C_{(LV2-G)} + C_{(LV2-H)}$	**GST**	LV2	H.V	LV1	10 KV
8	$C_{(LV2-G)}$	**GST**	LV2		H.V.LV1	10 KV
9	$C_{(LV2-H)}$	**UST**	LV2			10 KV

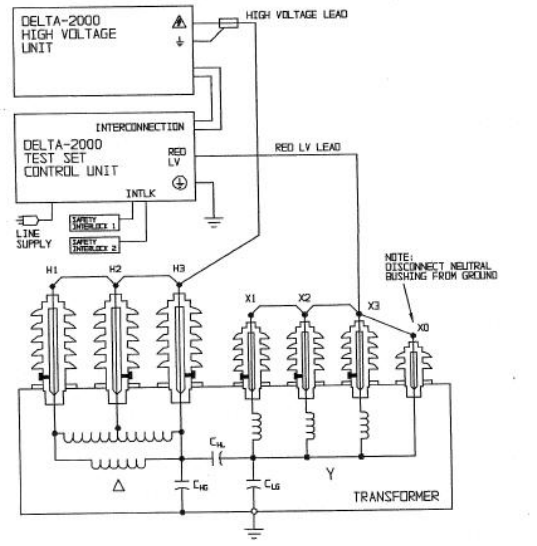
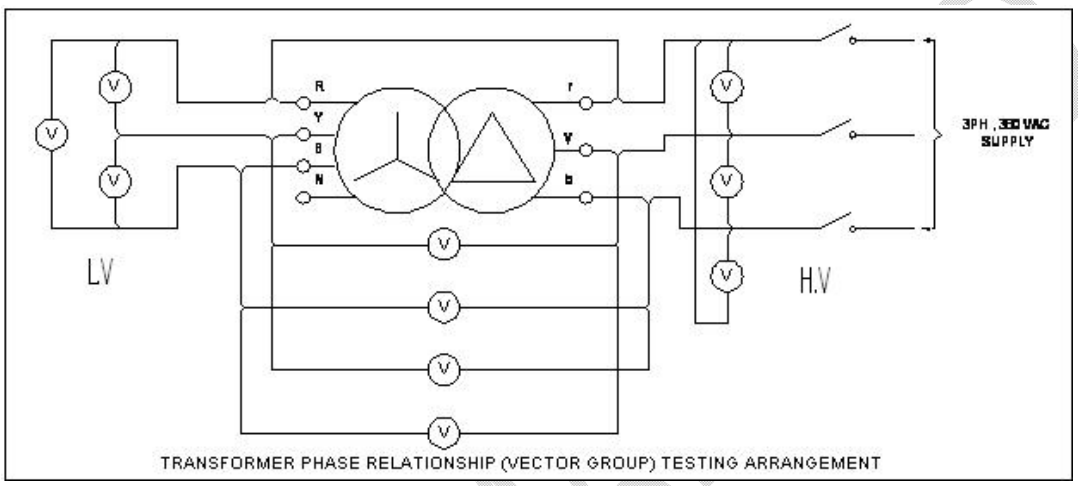


Figure 6: Typical Test Setup for Ac Insulation Testing of a Three-Phase Power Transformer

6. Vector Group Test

Test Equipment: Multi-meter.

- Short H.V terminal 1U and L.V terminal 2u.
- Tap. Changer in Normal Position (centre).
- Apply three phase voltage on H.V side, keep L.V side open.
- Measure and record the voltage between H.V phases and L.V phases
- Compare the voltage measurements against standard vector numbers



TRANSFORMER PHASE RELATIONSHIP (VECTOR GROUP) TESTING ARRANGEMENT

Phase relationship

1W-2w	<	1V-2w	=	1W-2v	>	1W-2w	<	1U-1V	0
1W-2w	<	1V-2w	>	1W-2v	=	1W-2w	<	1U-1V	1
1W-2w	<	1V-2w	>	1W-2v	<	1W-2w	<	1U-1V	2
1W-2w	<	1V-2w	>	1W-2v	<	1W-2w	≥	1U-1V	3
1W-2w	<	1V-2w	>	1W-2v	<	1W-2w	>	1U-1V	4
1W-2w	=	1V-2w	>	1W-2v	<	1W-2w	>	1U-1V	5
1W-2w	>	1V-2w	=	1W-2v	<	1W-2w	>	1U-1V	6
1W-2w	>	1V-2w	<	1W-2v	=	1W-2w	>	1U-1V	7
1W-2w	>	1V-2w	<	1W-2v	>	1W-2w	>	1U-1V	8
1W-2w	>	1V-2w	<	1W-2v	>	1W-2w	≥	1U-1V	9
1W-2w	>	1V-2w	<	1W-2v	>	1W-2w	<	1U-1V	10
1W-2w	=	1V-2w	<	1W-2v	>	1W-2w	<	1U-1V	11

7. Calibration of winding temp. Indicators

7.1 Calibration by heating

Test Equipment: Oil bath, Standard Thermometer

- Remove the winding temp. Sensors and put it inside oil bath.
- Use heater to increase the oil temp. And check the readings of temp indicators against standard thermometer.
- The max allowed deviation should be less than±3˚C.

7.2 Calibration by current injection

Test Equipment: Secondary Current Injection tester.

- Adjust the value of the Adjustable resistance inside WTI as manufacture settings.
- Make sure that the oil thermo-well is partially filled with oil.
- Isolate the C.T secondary wires inside the WTI.
- Record the oil temp. at the start of injection.
- Inject full-load secondary current for H.V winding to current input of W.T.I
- Record the H.V temp. Indicator reading every 5 min. for 45 min.
- Record the oil temp at the end of injection
- Calculate the gradient as follows
- Gradient = deviation in H.V temp. - Deviation in oil temp
- The gradient should match the manufacture setting ±3˚C
- Repeat for L.V and T.V Indicators.

8. Calibration of Oil temp. Device

Test Equipment: Oil bath, Standard Thermometer

- Remove the Oil temp. Sensors and put it inside oil bath.
- Use heater to increase the oil temp. and check the readings of temp indicators against standard thermometer
- The max allowed deviation should be less than±3˚C

9. Percentage Impedance Test

Test Equipment: Multi-meter, Clamp-meter

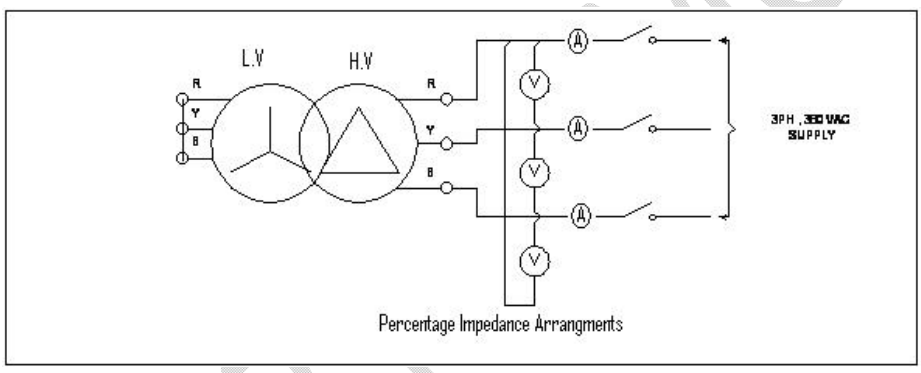
- The test will be done on lowest, nominal and highest tap position
- Short the L.V side and apply three phase supply to H.V side
- Measure the applied voltage and currents on H.V side
- Calculate the impedance voltage as follows

Impedance voltage= (average applied voltage÷ average applied current)x H.V Rated current

- Calculate the percentage Impedance %

Percentage Impedance % = (Impedance voltage÷ H.V Rated Voltage @tap pos) x 100

The value should match the factory test results



Percentage Impedance Arrangments

10. Turns Ratio Test

Test Equipment: Digital Three Phase TTR
- Connect high voltage cables “H1, H2, H3, H0” to H.V side

- Connect low voltage cables “x1, x2, x3, and x0” to L.V side
- On configuration menu select vector group for the transformer and enter the nominal voltage, number of tap positions
- Start the test and record the turn’s ratio at each tap potion
- Record the excitation current during each ratio test
- Repeat the test for each tap position
- The max allowed error is± 0.5%

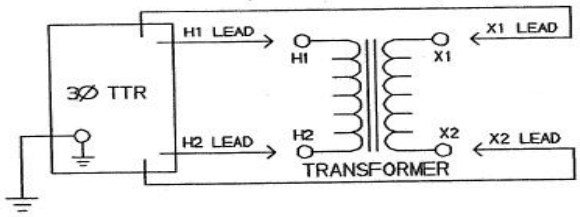


Figure 5-1. Setup for Testing Single-Phase Transformer

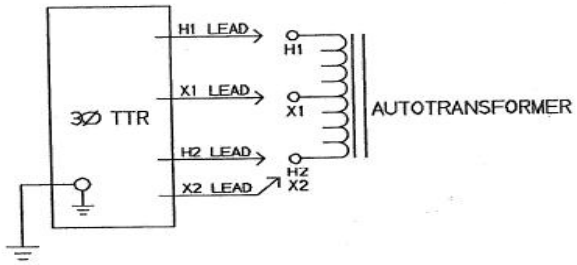


Figure 5-2. Setup for Testing Single-Phase Autotransformer

11. Check for current and voltage ratings for all motors of OLTC and fans match to SEC standard supply, check that MCBs for protection are set for proper over load settings

12. Fan motor currents shall be measured and checked against rating, check wiring size is adequate to carry the current

13. Check that the phase sequence of supply voltage to the fan motors of correct, check fan rotation direction and confirm air flow is towards radiator

14. MCBs in cooler control cubicle to be checked by current injection for alarm and trip

15. On-Load taps Changer tests

15.1. Check current and voltage rating of tap changer motor
15.2. Raise/Lower Control (local-remote) and indication
15.3. End of tap travel control
15.4. End of winding travel control
15.5. Check that windings are not open circuit during tap changing during winding resistance test

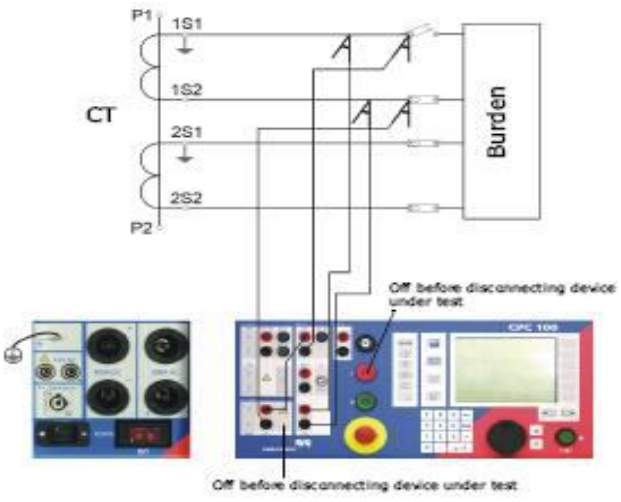
16. Bushing Current Transformer Tests

Test Equipment: Multi-Function Tester CPC 100

16.1. Polarity
- will be checked during ration test for bushing C.Ts

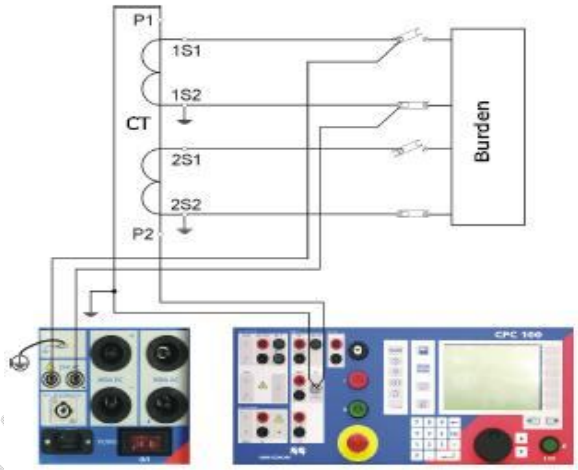
16.2. Insulation resistance:
-Short terminals (s1-s2) of the BCT to be tested
- Connect to +ve terminal of Insulation tester and connect –ve terminal to gorund - Ground the Power phase of the transformer and all other C.Ts on the same phase under test
- Apply 1000v and record the insulation resistance at 1min.

16.3. Secondary winding resistance :
- Using CPC100, connect the terminals to (s1-s2) as indicated and record the resistance at ambient temp.
- Refer the reading to 75˚C
- Repeat for all taps of BCT



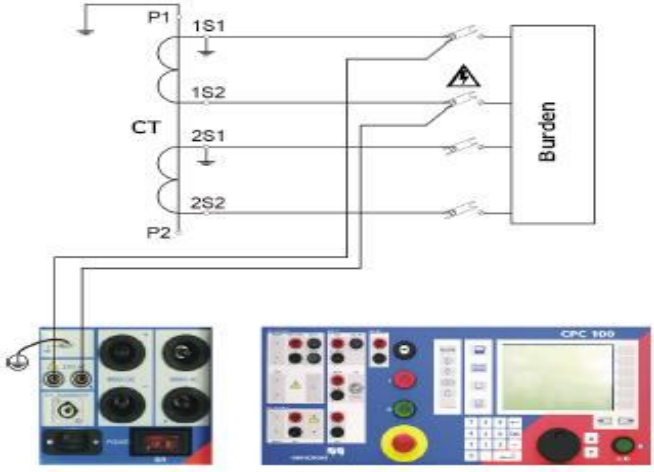
16.4. BC.T Ratio:

- Using CPC100 as shown below
- Connect high voltage cable to (s1-s2) and sensing cable to power terminal of tested phase “same polarity”
- Gradually Inject 75% of the knee-point voltage on the secondary terminals (s1-s2) with the correct polarity and measure the induced voltage (mV) on the power terminals
- The ratio will be shown on the screen and the percentage error
- Also the polarity will be shown as OK or FAILED



16.5. Magnetization Characteristics:

- Using CPC100, connect high voltage cable to (s1-s2) and select auto mode.
- The voltage will be gradually increase and the magnetising current will be measured till the knee point and the graph will be shown on the screen,
- Save the results and then make print-out



16.6. Verify secondary circuits, terminal to terminal
16.7. Perform burden test for secondary circuits

17. Perform functional checks for the following:

17.1. Liquid level (alarm-trip)
17.2. Top Oil Temperature Device (start, stop, alarm and trip) micro-switches
17.3. Winding temp. Devices
17.4. Buchloz relay (alarm-trip)
17.5. Oil/gas pressure relay (alarm-trip)
17.6. Pressure relief device (alarm-trip)

18. Insulation Oil Tests

-Several oil sample shall be taken form main tank (top, bottom), OLTC, conservator
And perform the following

18.1. Dielectric strength
18.1. a. ASTM 877 (2.5 mm gap) for unprocessed oil and OLTC oil
18.1. b. ASTM D 1816 (1.0 mm gap) for main tank oil
18.2. Neutralization Number (ASTM D 974)
18.3. Interfacial Tension (ASTM D 971)
18.4. Colour (ASTM D 1500)
18.5. Moisture content (ASTM D 1533)
18.6. Power Factor Test (ASTM D 924)
18.7. Dissolved Gas in Oil Analysis (ASDM D3 612)
18.8. Dielectric Dissipation Factor, Resistivity, Sediment and/or Perceptible Sludge

19. A main tank insulation oil sample for dissolved gas analysis shall be taken immediately prior to first energising a power transformer and another sample three days after continuous energization.